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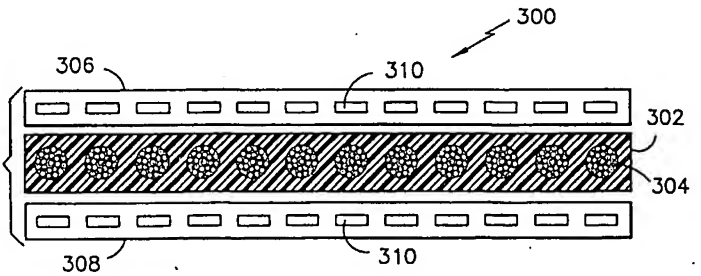
(54) Title: METHOD AND APPARATUS FOR DETECTING ELEVATOR ROPE DEGRADATION USING ELECTRICAL OR MAGNETIC ENERGY




(57) Abstract

A method and system for detecting or measuring defects in a rope having ferromagnetic tension members includes a magnetic field exciter and an array of magnetic flux sensors corresponding to the tension members in a known relationship. Measurements of magnetic flux leakage are indicative of defects. Another aspect of the invention includes a method and system for detecting or measuring defects in an elevator rope having electrically conductive tension members, whereby measured electrical resistance in the tension members is indicative of defects.

# INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 00/07279

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01N27/82

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
WPI Data, PAJ, EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | DE 39 04 612 A (WESTFÄLISCHE BERGWERKSSCHAFTSKASSE) 29 March 1990 (1990-03-29) abstract column 3, line 48 -column 4, line 46; figure 1 --- | 1-4, 6-12, 14-16,18 |
| A | EP 0 845 672 A (NORANDA INC) 3 June 1998 (1998-06-03) abstract column 4, line 16 - line 40; figure 1 --- | 1-4,6-20 |
| A | EP 0 286 712 A (WESTFÄLISCHE BERGWERKSGESELLSCHAFT) 19 October 1988 (1988-10-19) abstract column 4, line 15 - line 31; figure 1 ----- | 1-4,6-20 |

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 3 August 2000 | 12.01.01 |

| Name and mailing address of the ISA | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,<br>Fax: (+31-70) 340-3016 | KEMPF G.V. |

Form PCT/ISA/210 (second sheet) (July 1992)

# INTERNATIONAL SEARCH REPORT

Ir · ational application No.
PCT/US 00/07279

**Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)**

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-4,6-20

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-4,6-20

   A method and apparatus for detecting degradation of a rope applying a magnetic field.

2. Claim : 5

   A methode for approximating tension-load bearing capacity of a rope by applying a magnetic field.

3. Claims: 21-31

   A method for approximating the tension-load-bearing capacity of a rope applying a electric current.

4. Claim : 32

   A monitoring system for monitoring the level of exitation of an elevator.

# INTERNATIONAL SEARCH REPORT

ormation on patent family members

International Application No
PCT/US 00/07279

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| DE 3904612 A | 29-03-1990 | NONE | |
| EP 845672 A | 03-06-1998 | US 5804964 A | 08-09-1998 |
| | | BR 9706053 A | 14-09-1999 |
| | | CA 2222108 A | 29-05-1998 |
| | | ZA 9710734 A | 17-07-1998 |
| EP 286712 A | 19-10-1988 | NONE | |

WHAT IS CLAIMED IS :

1) A method of detecting degradation of a rope comprising a plurality of ferromagnetic cord members, said method comprising

applying a magnetic field to a portion of said cord members;

monitoring magnetic flux associated with said magnetic field; and

identifying locations along said cord members exhibiting magnetic flux leakage, wherein said locations are indicative of degradation.

2) A method according to claim 1, wherein

said magnetic field is applied by relative movement between said rope and a magnet.

3) A method according to claim 1, wherein

said rope comprises a body of non-ferromagnetic insulator material having a generally rectangular cross-section in which said plurality of ferromagnetic cord members are distributed and extend longitudinally therewith.

4) A method of detecting and locating degradation of a rope comprising a plurality of ferromagnetic cord members, said method comprising

causing said rope to move at a known rate relative to a magnet in order to apply a magnetic field to a portion of said cord members;

monitoring magnetic flux associated with said magnetic field as a function of time; and

identifying points in time in which said cord members exhibit magnetic flux leakage, wherein said points in time are indicative of the location of rope degradation.

5) A method for approximating tension-load bearing capacity of a rope comprising a plurality of ferromagnetic cord members, said method comprising

applying a magnetic field to a portion of said cord members;

measuring magnetic flux associated with said magnetic field; and

comparing said measured magnetic flux leakage to predetermined data indicative of tension-load bearing capacity.

6) A method of detecting and locating degradation of a rope comprising a plurality of ferromagnetic cord members, said method comprising

applying a magnetic field to a portion of said cord members;

monitoring magnetic flux associated with said magnetic field;

identifying locations along each individual cord member exhibiting magnetic flux leakage, wherein said locations are indicative of degradation; and

correlating said locations indicative of degradation of individual cord members with respect to each other to determine relative locations of each.

7) A method according to claim 3, further comprising

measuring the magnitude of said magnetic flux leakage.

8) A method according to claim 4, further comprising

measuring the magnitude of said magnetic flux leakage.

9) A method according to claim 6, further comprising

measuring the magnitude of said magnetic flux leakage.

10) An apparatus for detecting and locating degradation of a rope having at least one ferromagnetic component, said apparatus comprising

a body comprising rope guide means for guiding said rope along said body;

a magnet fixed with respect to said body for establishing a magnetic field adjacent to said body;

magnetic flux sensing means mounted with respect to said body for monitoring magnetic flux associated with said magnetic field; and

means for correlating said magnetic flux with said rope to determine one or more locations of degradation.

11) An apparatus according to claim 10, wherein

said rope comprises a plurality of ferromagnetic cord members.

12) An apparatus according to claim 11, wherein

said magnetic flux sensing means comprise a plurality of magnetic flux sensors mounted to said body.

13) An apparatus according to claim 12, wherein

said magnetic flux sensors comprise Hall effect transducers.

14) An apparatus according to claim 12, wherein

said plurality of magnetic flux sensors each correspond to one of said ferromagnetic cord members such that each magnetic flux sensor monitors the magnetic flux of a respective one of said cord members.

15) An apparatus according to claim 14, further comprising

control means for correlating the magnetic flux detected by each of said magnetic flux sensors.

16) An apparatus according to claim 14, wherein

said plurality of magnetic flux sensors are positioned with respect to said body so that they remain on one side of said rope when it is guided along said body.

17) An apparatus according to claim 14, wherein

said plurality of magnetic flux sensors are positioned with respect to said body so that they are on opposing sides of said rope when it is guided along said body.

18) An apparatus according to claim 10, further comprising

means for mounting said apparatus in an elevator assembly in such a manner as to enable it to engage an installed elevator rope with said rope guide means for detecting and locating degradation of said elevator rope.

19) An apparatus according to claim 10, further comprising

means for mounting said apparatus to an elevator hoist machine assembly in an elevator assembly in such a manner as to enable it to engage an installed elevator rope with said rope guide means for detecting and locating degradation of said elevator rope.

20) An apparatus according to claim 10, wherein

said apparatus is a self-contained, portable unit adapted to be transported to and from an elevator assembly for use therewith to enable it to engage an installed elevator rope with said rope guide means for detecting and locating degradation of said elevator rope.

21) A method for approximating the tension-load bearing capacity of an elevator rope comprising an electrically-conductive, tension-bearing component, said method comprising

applying an electric current through said elevator rope ;

determining electrical resistivity of said elevator rope ; and

comparing said resistivity to predetermined data indicative of tension-load bearing capacity of said elevator rope.

22) A method according to claim 21, further comprising

connecting current input and current output leads at dead-end hitch points, respectively, of said elevator rope in an elevator assembly.

23) A method according to claim 21, wherein

said electrically-conductive component is a tension-bearing cord in an elevator rope, wherein said tension-bearing member supports the load of the elevator car.

24) A method according to claim 21, wherein

said elevator rope further comprises a non-conductive insulating jacket generally surrounding said electrically-conductive, tension-bearing component.

25) A system for approximating tension-load bearing capacity of an elevator rope having two fixed ends in an elevator assembly and comprising an electrically-conductive component, said system comprising

means for applying electric current through a section of said elevator rope ;

means for measuring electrical resistivity of said elevator rope ; and

means for correlating said measurement of said resistivity to predetermined data indicative of tension-load bearing strength of said elevator rope.

26) A system according to claim 25, wherein

said electrically-conductive component is a tension-bearing member cord in an elevator rope, wherein said tension-bearing member supports the load of the elevator car.

27) A system according to claim 25, wherein

said elevator rope further comprises a non-conductive insulating jacket generally surrounding said electrically-conductive, tension-bearing component.

28) A system according to claim 25, wherein

said electrically-conductive, tension-bearing component of said elevator rope comprises a plurality of cords embedded within and running longitudinally along the length of said elevator rope for supporting the load of an elevator car; and

said means for applying electric current through a section of said elevator rope engage each of said cords to apply electric current therethrough.

29) A system according to claim 25, further comprising

means for engaging said two fixed ends of said elevator rope for applying said electric current through said elevator rope.

30) A system according to claim 25, further including

means for comparing said measurement of said resistivity for each cord with the others and determining the relative tension-load bearing strengths of each with respect to the others.

31) A system according to claim 28, wherein

said elevator rope further comprises a non-conductive insulating jacket generally surrounding said plurality of cords.

32) A monitoring system for monitoring the level of excitation of an elevator rope having a load-bearing element that supports the tension loads of the elevator system and a jacket that encompasses the load-bearing element, said monitoring system comprising

excitation means for exciting said load-bearing element in a manner such that said jacket is not subject to excitation; and

monitoring means for monitoring the level of excitation of said load-bearing element.

FIG.1


FIG.2

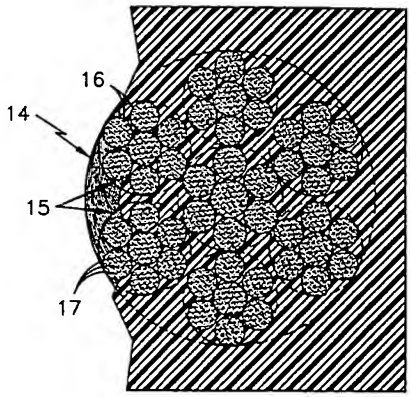



FIG.3

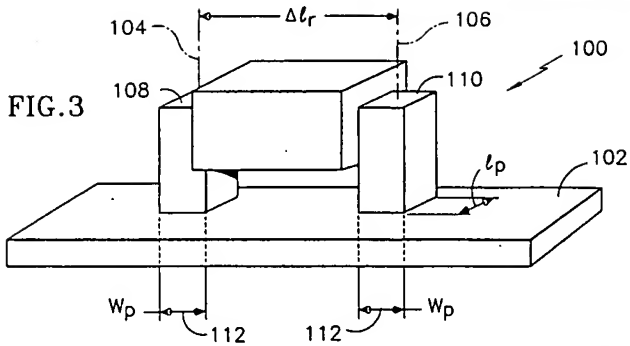



FIG.4